REMARKS

Claims 1-12 are amended herein. Claims 1-12 remain pending in the application.

Claims 1-12 over Chen

In the Office Action, claims 1-12 were rejected under 35 U.S.C. §102(b) as allegedly being anticipated by Chen et al. U.S. Patent No. 5,500,900 ("Chen"). The Applicant respectfully traverses the rejection.

Claims 1-4 recite, *inter alia,* a plurality of time domain spatial characteristic functions that are adaptively combined with a plurality of Eigen filters.

Chen appears to teach a free-field-to-eardrum transfer function (FETF) developed by comparing auditory data for points in three-dimensional space for a model ear and auditory data collected for the same listening location with a microphone (Abstract). Each FETF is represented as a weighted sum of frequency-dependent functions obtained from an expansion of a measured FEFT covariance matrix (Chen, Abstract). Spatial transformation characteristic functions (STCF) are applied to transform the weighted frequency-dependent factors to functions of spatial variables for azimuth and elevation (Chen, Abstract). A generalized spline model is fit to each STCF to filter out noise and permit interpolation of the STCF between measured points (Chen, Abstract). A spline model used to generate the STCFs, smooths measurement noise and enables interpolation of the STCFs between measurement directions (Chen, col. 5, lines 18-20). A regularizing parameter within the spline model controls a trade-off between smoothness of a solution and its fidelity to the data (Chen, col. 5, lines 29-31).

Chen teaches use of frequency domain functions, frequency domain filtering of components, with time domain filtering as an alternative (Chen, col. 6, lines 56-60). Chen fails to teach a plurality of time domain spatial characteristic functions that are adaptively combined with a plurality of Eigen filters, as claimed by claims 1-4.

Claims 5-8 recite, inter alia, a plurality of time domain spatial characteristic functions are adapted to be respectively combined with a plurality of Eigen filters.

As discussed above, Chen teaches use of frequency domain filtering of components, with time domain filtering as an alternative. Chen fails to teach a plurality of time domain spatial characteristic functions are adapted to be respectively combined with a plurality of Eigen filters, as claimed by claims 5-8.

Claims 9-12 respectively recite, *inter alia*, constructing a covariance data matrix of a plurality of measured time domain head-related transfer functions and constructing a time domain covariance data matrix of a plurality of measured head-related impulse responses.

Chen appears to teach choosing Eigen filters as Eigen vectors corresponding to the largest Eigen values of a sample covariance matrix formed from spatial samples of FETF frequency vectors (col. 4, lines 39-43). The Eigen vectors are processed to calculate samples of the STCFs as a function of spatial variables for each direction from which sound has been measured (Chen, col. 5, lines 56-60). A generalized spline model is fit to the STCF samples using a commercial software package (Chen, col. 5, line 66-col. 6, line 1). The spline model filters out noise from each of the sampled STCFs, producing continuous functions of spatial variables (Chen, col. 6, lines 3-5).

Chen teaches use of frequency domain functions. Chen fails to teach constructing a covariance data matrix of a plurality of measured time domain head-related transfer functions and constructing a time domain covariance data matrix of a plurality of measured head-related impulse responses, as respectively claimed by claims 9-12.

A benefit of utilizing time domain functions, versus Chen's use of frequency domain functions, is, e.g., that they are simpler to derive since not requiring complex number crunching and are computationally cheaper to implement. Though it is principally correct, generalized spline is an expensive calculation in a real-time sense. The Applicant's invention allows use of a generalized spline model in a low cost real-time implementation. Since linear interpolation is a moderate operation in terms of number of instructions needed,

the Applicant's invention practically addresses a real-time implementation issue of producing 3D sound digitally, yet preserves the theoretical advantages of the prior art.

Accordingly, for at least all the above reasons, claims 1-12 are patentable over the prior art of record. It is therefore respectfully requested that the rejection be withdrawn.

Conclusion

All objections and rejections having been addressed, it is respectfully submitted that the subject application is in condition for allowance and a Notice to that effect is earnestly solicited.

Respectfully submitted,

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<u>Version with Markings to Show Changes Made</u>

1. (Amended) A <u>time domain</u> head-related transfer function model for use with 3D sound applications, comprising:

a plurality of Eigen filters;

a plurality of <u>time domain</u> spatial characteristic functions are adaptively combined with said plurality of Eigen filters; and

a plurality of regularizing models adapted to regularize said plurality of <u>time domain</u> spatial characteristic functions prior to said respective combination with said plurality of Eigen filters.

2. (Amended) The <u>time domain</u> head-related transfer function model for use with 3D sound applications according to claim 1, further comprising:

a summer operably coupled to said plurality of combined Eigen filters combined with said plurality of regularized <u>time domain</u> spatial characteristic functions to provide said <u>time domain</u> head-related transfer function model.

3. (Amended) The <u>time domain</u> head-related transfer function model for use with 3D sound applications according to claim 1, wherein:

said plurality of regularizing models are each adapted to perform a generalized spline model.

4. (Amended) The <u>time domain</u> head-related transfer function model for use with 3D sound applications according to claim 1, further comprising:

a smoothness control operably coupled with said plurality of regularizing models to allow control of a trade-off between localization and smoothness of said head-related transfer function.

5. (Amended) A time domain head-related impulse response model for use with 3D sound applications, comprising:

a plurality of Eigen filters;

a plurality of time domain spatial characteristic functions are adapted to be respectively combined with said plurality of Eigen filters; and

a plurality of regularizing models adapted to regularize said plurality of time domain spatial characteristic functions prior to said respective combination with said plurality of Eigen filters.

6. (Amended) The time domain head-related impulse response model for use with 3D sound applications according to claim 5, further comprising:

a summer adapted to sum said plurality of combined Eigen filters combined with said plurality of regularized time domain spatial characteristic functions to provide said head-related impulse response model.

7. (Amended) The time domain head-related impulse response model for use with 3D sound applications according to claim 5, wherein:

said plurality of regularizing models are each adapted to perform a generalized spline model.

8. (Amended) The time domain head-related transfer function model for use with 3D sound applications according to claim 5, further comprising:

a smoothness control in communication with said plurality of regularizing models to allow control of a trade-off between localization and smoothness of said time domain head-related transfer function.

9. (Amended) A method of determining spatial characteristic sets for use in a time domain head-related transfer function model, comprising:

constructing a covariance data matrix of a plurality of measured time domain head-related transfer functions;

performing an Eigen decomposition of said covariance data matrix to provide a plurality of Eigen vectors;

determining at least one principal Eigen vector from said plurality of Eigen vectors; and

projecting said measured time domain head-related transfer functions back to said at least one principal Eigen vector to create said spatial characteristic sets.

10. (Amended) A method of determining spatial characteristic sets for use in a time domain head-related impulse response model, comprising:

constructing a time domain covariance data matrix of a plurality of measured head-related impulse responses;

performing an Eigen decomposition of said time domain covariance data matrix to provide a plurality of Eigen vectors;

determining at least one principal Eigen vector from said plurality of Eigen vectors; and

back-projecting said measured head-related impulse responses to said at least one principal Eigen vector to create said spatial characteristic sets.

11. (Amended) Apparatus for determining spatial characteristic sets for use in a <u>time domain</u> head-related transfer function model, comprising:

means for constructing a covariance data matrix of a plurality of measured <u>time domain</u> head-related transfer functions;

means for performing an Eigen decomposition of said covariance data matrix to provide a plurality of Eigen vectors;

means for determining at least one principal Eigen vector from said plurality of Eigen vectors; and

means for back-projecting said measured <u>time domain</u> head-related transfer functions to said at least one principal Eigen vector to create said spatial characteristic sets.

12. (Amended) Apparatus for determining spatial characteristic sets for use in a <u>time domain</u> head-related impulse response model, comprising:

means for constructing a <u>time domain</u> covariance data matrix of a plurality of measured head-related impulse responses;

means for performing an Eigen decomposition of said <u>time domain</u> covariance data matrix to provide a plurality of Eigen vectors;

means for determining at least one principal Eigen vector from said plurality of Eigen vectors; and

means for back-projecting said measured head-related impulse responses to said at least one principal Eigen vector to create said spatial characteristic sets.